

Refine Search

Search Results -

Terms	Documents
L1 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	23

Database:

US Pre-Grant Publication Full-Text Database
 US Patents Full-Text Database
 US OCR Full-Text Database
 EPO Abstracts Database
 JPO Abstracts Database
 Derwent World Patents Index
 IBM Technical Disclosure Bulletins

Search:

L3

Refine Search

Recall Text

Clear

Interrupt

Search History

DATE: Monday, January 16, 2006 [Printable Copy](#) [Create Case](#)

<u>Set</u> <u>Name</u> side by side	<u>Query</u>	<u>Hit</u> <u>Count</u>	<u>Set</u> <u>Name</u> result set
<i>DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=NO; OP=OR</i>			
<u>L3</u>	L1 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	23	<u>L3</u>
<u>L2</u>	L1 (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	1911	<u>L2</u>
<u>L1</u>	382/159	912	<u>L1</u>

END OF SEARCH HISTORY

Refine Search

Search Results -

Terms	Documents
L7 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	12

Database:

US Pre-Grant Publication Full-Text Database
 US Patents Full-Text Database
 US OCR Full-Text Database
 EPO Abstracts Database
 JPO Abstracts Database
 Derwent World Patents Index
 IBM Technical Disclosure Bulletins

Search:

L8

Refine Search

Recall Text

Clear

Interrupt

Search History

 DATE: Monday, January 16, 2006 [Printable Copy](#) [Create Case](#)

<u>Set Name</u> side by side	<u>Query</u>	<u>Hit Count</u>	<u>Set Name</u> result set
<i>DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=NO; OP=OR</i>			
<u>L8</u>	L7 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	12	<u>L8</u>
<u>L7</u>	382/253	654	<u>L7</u>
<u>L6</u>	L5 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	7	<u>L6</u>
<u>L5</u>	382/160	226	<u>L5</u>
<u>L4</u>	L3 and quant\$	16	<u>L4</u>
<u>L3</u>	L1 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	23	<u>L3</u>
<u>L2</u>	L1 (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	1911	<u>L2</u>
<u>L1</u>	382/159	912	<u>L1</u>

END OF SEARCH HISTORY

Hit List

First Hit

Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Clear

Generate Collection

Print

Fwd Refs

Bkwd Refs

Generate OACS

Search Results - Record(s) 1 through 16 of 16 returned.☐ 1. Document ID: US 20040120572 A1

Using default format because multiple data bases are involved.

L4: Entry 1 of 16

File: PGPB

Jun 24, 2004

PGPUB-DOCUMENT-NUMBER: 20040120572

PGPUB-FILING-TYPE: new

DOCUMENT-IDENTIFIER: US 20040120572 A1

TITLE: Method for using effective spatio-temporal image recomposition to improve scene classification

PUBLICATION-DATE: June 24, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Luo, Jiebo	Pittsford	NY	US
Gray, Robert T.	Rochester	NY	US
Boutell, Matthew R.	Rochester	NY	US

US-CL-CURRENT: 382/159; 382/224

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	------	--------

☐ 2. Document ID: US 6915025 B2

L4: Entry 2 of 16

File: USPT

Jul 5, 2005

US-PAT-NO: 6915025

DOCUMENT-IDENTIFIER: US 6915025 B2

TITLE: Automatic image orientation detection based on classification of low-level image features

DATE-ISSUED: July 5, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
------	------	-------	----------	---------

Wang; Yongmei Hong Kong HK
Zhang; Hong-Jiang Beijing CN

US-CL-CURRENT: 382/289; 382/165, 382/190

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 3. Document ID: US 6847680 B2

L4: Entry 3 of 16

File: USPT

Jan 25, 2005

US-PAT-NO: 6847680

DOCUMENT-IDENTIFIER: US 6847680 B2

TITLE: Method for detecting talking heads in a compressed video

DATE-ISSUED: January 25, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Divakaran; Ajay	Denville	NJ		
Radhakrishnan; Regunathan	Ozone Park	NY		

US-CL-CURRENT: 375/240.01; 375/240.08

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 4. Document ID: US 6816847 B1

L4: Entry 4 of 16

File: USPT

Nov 9, 2004

US-PAT-NO: 6816847

DOCUMENT-IDENTIFIER: US 6816847 B1

TITLE: computerized aesthetic judgment of images

DATE-ISSUED: November 9, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Toyama; Kentaro	Redmond	WA		

US-CL-CURRENT: 706/14; 382/156, 382/157, 382/158, 382/159, 382/224, 706/18, 706/20

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 5. Document ID: US 6760714 B1

L4: Entry 5 of 16

File: USPT

Jul 6, 2004

US-PAT-NO: 6760714

DOCUMENT-IDENTIFIER: US 6760714 B1

**** See image for Certificate of Correction ****TITLE: Representation and retrieval of images using content vectors derived from image information elements

DATE-ISSUED: July 6, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Caid; William R.	San Diego	CA		
Hecht-Neilsen; Robert	Del Mar	CA		

US-CL-CURRENT: 706/14; 382/116, 382/228

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 6. Document ID: US 6751354 B2

L4: Entry 6 of 16

File: USPT

Jun 15, 2004

US-PAT-NO: 6751354

DOCUMENT-IDENTIFIER: US 6751354 B2

TITLE: Methods and apparatuses for video segmentation, classification, and retrieval using image class statistical models

DATE-ISSUED: June 15, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Foote; Jonathan T.	Menlo Park	CA		
Wilcox; Lynn	Portola Valley	CA		
Girgensohn; Andreas	Menlo Park	CA		

US-CL-CURRENT: 382/224; 348/395.1, 348/405.1, 348/408.1, 382/190, 382/209, 382/218, 382/220

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 7. Document ID: US 6640145 B2

L4: Entry 7 of 16

File: USPT

Oct 28, 2003

US-PAT-NO: 6640145

DOCUMENT-IDENTIFIER: US 6640145 B2

TITLE: Media recording device with packet data interface

DATE-ISSUED: October 28, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hoffberg; Steven	West Harrison	NY	10604	
Hoffberg-Borghesani; Linda	Acton	MA	01720	

US-CL-CURRENT: 700/83; 700/17, 700/19, 700/23, 704/200, 704/201, 704/7, 709/200,
709/201, 709/202

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 8. Document ID: US 6487545 B1

L4: Entry 8 of 16

File: USPT

Nov 26, 2002

US-PAT-NO: 6487545

DOCUMENT-IDENTIFIER: US 6487545 B1

TITLE: Methods and apparatus for classifying terminology utilizing a knowledge catalog

DATE-ISSUED: November 26, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Wical; Kelly	Redwood Shores	CA		

US-CL-CURRENT: 706/45

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 9. Document ID: US 6418424 B1

L4: Entry 9 of 16

File: USPT

Jul 9, 2002

US-PAT-NO: 6418424

DOCUMENT-IDENTIFIER: US 6418424 B1

TITLE: Ergonomic man-machine interface incorporating adaptive pattern recognition based control system

DATE-ISSUED: July 9, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hoffberg; Steven M.	West Harrison	NY	10604	
Hoffberg-Borghesani; Linda I.	Acton	MA	01720	

US-CL-CURRENT: 706/21; 434/178, 706/52

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 10. Document ID: US 6404925 B1

L4: Entry 10 of 16

File: USPT

Jun 11, 2002

US-PAT-NO: 6404925

DOCUMENT-IDENTIFIER: US 6404925 B1

TITLE: Methods and apparatuses for segmenting an audio-visual recording using image similarity searching and audio speaker recognition

DATE-ISSUED: June 11, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Foote; Jonathan T.	Menlo Park	CA		
Wilcox; Lynn	Portola Valley	CA		

US-CL-CURRENT: 382/224; 348/480, 348/484, 358/403, 382/159, 382/173, 382/190, 382/197, 382/209, 382/225, 382/227, 382/276, 382/305, 704/239, 704/243, 704/245, 707/1, 707/3

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWAC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 11. Document ID: US 6400996 B1

L4: Entry 11 of 16

File: USPT

Jun 4, 2002

US-PAT-NO: 6400996

DOCUMENT-IDENTIFIER: US 6400996 B1

TITLE: Adaptive pattern recognition based control system and method

DATE-ISSUED: June 4, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hoffberg; Steven M.	West Harrison	NY	10994	
Hoffberg-Borghesani; Linda I.	Acton	MA	01720	

US-CL-CURRENT: 700/83; 370/218, 370/355, 700/17, 700/24, 700/25, 700/86, 700/87, 709/223, 709/227, 715/810, 715/840, 715/841, 718/102, 719/318

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWAC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 12. Document ID: US 6397200 B1

L4: Entry 12 of 16

File: USPT

May 28, 2002

US-PAT-NO: 6397200

DOCUMENT-IDENTIFIER: US 6397200 B1

TITLE: Data reduction system for improving classifier performance

DATE-ISSUED: May 28, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Lynch, Jr.; Robert S.	Groton	CT		
Willett; Peter K.	Coventry	CT		

US-CL-CURRENT: 706/20; 702/181

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	------

☐ 13. Document ID: US 6173275 B1

L4: Entry 13 of 16

File: USPT

Jan 9, 2001

US-PAT-NO: 6173275

DOCUMENT-IDENTIFIER: US 6173275 B1

**** See image for Certificate of Correction ****TITLE: Representation and retrieval of images using context vectors derived from image information elements

DATE-ISSUED: January 9, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Caid; William R.	San Diego	CA		
Hecht-Neilsen; Robert	Del Mar	CA		

US-CL-CURRENT: 706/14; 382/190, 382/195, 382/224, 382/225, 706/12, 706/934

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	------

☐ 14. Document ID: US 6072542 A

L4: Entry 14 of 16

File: USPT

Jun 6, 2000

US-PAT-NO: 6072542

DOCUMENT-IDENTIFIER: US 6072542 A

TITLE: Automatic video segmentation using hidden markov model

DATE-ISSUED: June 6, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
------	------	-------	----------	---------

Wilcox; Lynn D. Portola Valley CA
Boreczky; John S. San Leandro CA

US-CL-CURRENT: 348/722; 348/700, 348/701, 382/155, 382/156, 382/157, 382/160,
386/68, 386/69, 386/95, 386/96

Full	Title	Citation	Front	Review	Classification	Date	Reference				Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--	--------	------	--------

☐ 15. Document ID: US 5987459 A

L4: Entry 15 of 16

File: USPT

Nov 16, 1999

US-PAT-NO: 5987459

DOCUMENT-IDENTIFIER: US 5987459 A

**** See image for Certificate of Correction ****

TITLE: Image and document management system for content-based retrieval

DATE-ISSUED: November 16, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Swanson; Mitchell D.	Minneapolis	MN		
Tewfik; Ahmed H.	Edina	MN		
Hosur; Srinath	Plano	TX		

US-CL-CURRENT: 707/6; 707/3, 707/9

Full	Title	Citation	Front	Review	Classification	Date	Reference				Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--	--------	------	--------

☐ 16. Document ID: US 5822465 A

L4: Entry 16 of 16

File: USPT

Oct 13, 1998

US-PAT-NO: 5822465

DOCUMENT-IDENTIFIER: US 5822465 A

TITLE: Image encoding by vector quantization of regions of an image and codebook updates

DATE-ISSUED: October 13, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Normile; James Oliver	Sunnyvale	CA		
Wang; Katherine Shu-Wei	San Jose	CA		

US-CL-CURRENT: 382/253; 382/239

Full	Title	Citation	Front	Review	Classification	Date	Reference				Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--	--------	------	--------

[Clear](#)[Generate Collection](#)[Print](#)[Fwd Refs](#)[Bkwd Refs](#)[Generate OACS](#)

Terms	Documents
L3 and quant\$	16

Display Format: [Change Format](#)

[Previous Page](#)[Next Page](#)[Go to Doc#](#)

Hit List

[First Hit](#)[Clear](#)[Generate Collection](#)[Print](#)[Fwd Refs](#)[Bkwd Refs](#)[Generate OACS](#)

Search Results - Record(s) 1 through 7 of 7 returned.

☐ 1. Document ID: US 6751354 B2

Using default format because multiple data bases are involved.

L6: Entry 1 of 7

File: USPT

Jun 15, 2004

US-PAT-NO: 6751354

DOCUMENT-IDENTIFIER: US 6751354 B2

TITLE: Methods and apparatuses for video segmentation, classification, and retrieval using image class statistical models

DATE-ISSUED: June 15, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Foote; Jonathan T.	Menlo Park	CA		
Wilcox; Lynn	Portola Valley	CA		
Girgensohn; Andreas	Menlo Park	CA		

US-CL-CURRENT: 382/224; 348/395.1, 348/405.1, 348/408.1, 382/190, 382/209, 382/218, 382/220

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	Know	Draw
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	------

☐ 2. Document ID: US 6678413 B1

L6: Entry 2 of 7

File: USPT

Jan 13, 2004

US-PAT-NO: 6678413

DOCUMENT-IDENTIFIER: US 6678413 B1

TITLE: System and method for object identification and behavior characterization using video analysis

DATE-ISSUED: January 13, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Liang; Yiqing	Vienna	VA	22182	
Crnic; Linda	Denver	CO	80224	
Kobla; Vikrant	Ashburn	VA	20147	
Wolf; Wayne	Princeton	NJ	08540	

US-CL-CURRENT: 382/181; 348/169

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 3. Document ID: US 6574378 B1

L6: Entry 3 of 7

File: USPT

Jun 3, 2003

US-PAT-NO: 6574378

DOCUMENT-IDENTIFIER: US 6574378 B1

TITLE: Method and apparatus for indexing and retrieving images using visual keywords

DATE-ISSUED: June 3, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Lim; Joo Hwee	Singapore			SG

US-CL-CURRENT: 382/305; 358/403

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 4. Document ID: US 6081750 A

L6: Entry 4 of 7

File: USPT

Jun 27, 2000

US-PAT-NO: 6081750

DOCUMENT-IDENTIFIER: US 6081750 A

TITLE: Ergonomic man-machine interface incorporating adaptive pattern recognition based control system

DATE-ISSUED: June 27, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hoffberg; Steven Mark	Yonkers	NY	10701-1705	
Hoffberg-Borghesani; Linda Irene	Acton	MA	01720	

US-CL-CURRENT: 700/17; 345/520, 700/11, 700/56, 700/83, 700/86

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 5. Document ID: US 6072542 A

L6: Entry 5 of 7

File: USPT

Jun 6, 2000

US-PAT-NO: 6072542

DOCUMENT-IDENTIFIER: US 6072542 A

TITLE: Automatic video segmentation using hidden markov model

DATE-ISSUED: June 6, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Wilcox; Lynn D.	Portola Valley	CA		
Boreczky; John S.	San Leandro	CA		

US-CL-CURRENT: 348/722, 348/700, 348/701, 382/155, 382/156, 382/157, 382/160,
386/68, 386/69, 386/95, 386/96

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw Dg
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 6. Document ID: US 5875108 A

L6: Entry 6 of 7

File: USPT

Feb 23, 1999

US-PAT-NO: 5875108

DOCUMENT-IDENTIFIER: US 5875108 A

TITLE: Ergonomic man-machine interface incorporating adaptive pattern recognition based control system

DATE-ISSUED: February 23, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hoffberg; Steven M.	Yonkers	NY	10701-1705	
Hoffberg-Borghesani; Linda I.	Acton	MA	01720	

US-CL-CURRENT: 700/17, 382/181, 382/190, 700/83

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw Dg
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 7. Document ID: US 5822465 A

L6: Entry 7 of 7

File: USPT

Oct 13, 1998

US-PAT-NO: 5822465

DOCUMENT-IDENTIFIER: US 5822465 A

TITLE: Image encoding by vector quantization of regions of an image and codebook updates

DATE-ISSUED: October 13, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Normile; James Oliver	Sunnyvale	CA		
Wang; Katherine Shu-Wei	San Jose	CA		

US-CL-CURRENT: 382/253; 382/239

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KMIC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

Clear

Generate Collection

Print

Fwd Refs

Bkwd Refs

Generate OACS

Terms

Documents

L5 and (multimedia or multi-media) and
vector\$2 and train\$3 and classif\$8 and quant\$

7

Display Format:

-

Change Format

[Previous Page](#)[Next Page](#)[Go to Doc#](#)

Hit List

[First Hit](#)[Clear](#)[Generate Collection](#)[Print](#)[Fwd Refs](#)[Bkwd Refs](#)[Generate OACS](#)

Search Results - Record(s) 1 through 12 of 12 returned.

☐ 1. Document ID: US 6870962 B2

Using default format because multiple data bases are involved.

L8: Entry 1 of 12

File: USPT

Mar 22, 2005

US-PAT-NO: 6870962

DOCUMENT-IDENTIFIER: US 6870962 B2

TITLE: Method and apparatus for efficiently encoding chromatic images using non-orthogonal basis functions

DATE-ISSUED: March 22, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Lee; Te-Won	San Diego	CA		
Wachtler; Thomas	Freiburg			DE
Sejnowski; Terrence J.	Solana Beach	CA		

US-CL-CURRENT: 382/248; 382/233, 382/240

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KIMC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 2. Document ID: US 6826524 B1

L8: Entry 2 of 12

File: USPT

Nov 30, 2004

US-PAT-NO: 6826524

DOCUMENT-IDENTIFIER: US 6826524 B1

TITLE: Sample-adaptive product quantization

DATE-ISSUED: November 30, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Kim; Dong Sik	Sungnam-Si			KR
Shroff; Ness B.	Lafayette	IN		

US-CL-CURRENT: 704/200

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KIMC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 3. Document ID: US 6760714 B1

L8: Entry 3 of 12

File: USPT

Jul 6, 2004

US-PAT-NO: 6760714

DOCUMENT-IDENTIFIER: US 6760714 B1

**** See image for Certificate of Correction ****TITLE: Representation and retrieval of images using content vectors derived from image information elements

DATE-ISSUED: July 6, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Caid; William R.	San Diego	CA		
Hecht-Neilsen; Robert	Del Mar	CA		

US-CL-CURRENT: 706/14; 382/116, 382/228

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KM/C	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 4. Document ID: US 6738512 B1

L8: Entry 4 of 12

File: USPT

May 18, 2004

US-PAT-NO: 6738512

DOCUMENT-IDENTIFIER: US 6738512 B1

TITLE: Using shape suppression to identify areas of images that include particular shapes

DATE-ISSUED: May 18, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Chen; Xiangrong	Beijing			CN
Zhang; Hong-Jiang	Beijing			CN

US-CL-CURRENT: 382/176; 382/200, 382/203

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KM/C	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 5. Document ID: US 6571016 B1

L8: Entry 5 of 12

File: USPT

May 27, 2003

US-PAT-NO: 6571016

DOCUMENT-IDENTIFIER: US 6571016 B1

**** See image for Certificate of Correction ****

TITLE: Intra compression of pixel blocks using predicted mean

DATE-ISSUED: May 27, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Mehrotra; Sanjeev	Kirkland	WA		
Wang; Albert S.	Kirkland	WA		

US-CL-CURRENT: 382/236; 375/240.13

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KBAC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 6. Document ID: US 6404923 B1

L8: Entry 6 of 12

File: USPT

Jun 11, 2002

US-PAT-NO: 6404923

DOCUMENT-IDENTIFIER: US 6404923 B1

**** See image for Certificate of Correction ****

TITLE: Table-based low-level image classification and compression system

DATE-ISSUED: June 11, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Chaddha; Navin	Stanford	CA		

US-CL-CURRENT: 382/224; 382/240, 382/253

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KBAC	Draw De
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 7. Document ID: US 6397200 B1

L8: Entry 7 of 12

File: USPT

May 28, 2002

US-PAT-NO: 6397200

DOCUMENT-IDENTIFIER: US 6397200 B1

TITLE: Data reduction system for improving classifier performance

DATE-ISSUED: May 28, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Lynch, Jr.; Robert S.	Groton	CT		
Willett; Peter K.	Coventry	CT		

US-CL-CURRENT: 706/20; 702/181

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 8. Document ID: US 6173275 B1

L8: Entry 8 of 12

File: USPT

Jan 9, 2001

US-PAT-NO: 6173275

DOCUMENT-IDENTIFIER: US 6173275 B1

**** See image for Certificate of Correction ****TITLE: Representation and retrieval of images using context vectors derived from image information elements

DATE-ISSUED: January 9, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Caid; William R.	San Diego	CA		
Hecht-Neilsen; Robert	Del Mar	CA		

US-CL-CURRENT: 706/14; 382/190, 382/195, 382/224, 382/225, 706/12, 706/934

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 9. Document ID: US 5822465 A

L8: Entry 9 of 12

File: USPT

Oct 13, 1998

US-PAT-NO: 5822465

DOCUMENT-IDENTIFIER: US 5822465 A

TITLE: Image encoding by vector quantization of regions of an image and codebook updates

DATE-ISSUED: October 13, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Normile; James Oliver	Sunnyvale	CA		
Wang; Katherine Shu-Wei	San Jose	CA		

US-CL-CURRENT: 382/253; 382/239

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 10. Document ID: US 5802208 A

L8: Entry 10 of 12

File: USPT

Sep 1, 1998

US-PAT-NO: 5802208

DOCUMENT-IDENTIFIER: US 5802208 A

TITLE: Face recognition using DCT-based feature vectors

DATE-ISSUED: September 1, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Podilchuk; Christine Irene	Bridgewater	NJ		
Zhang; Xiaoyu	Piscataway	NJ		

US-CL-CURRENT: 382/224; 382/115, 382/250, 382/253

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw Dg
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 11. Document ID: US 5649030 A

L8: Entry 11 of 12

File: USPT

Jul 15, 1997

US-PAT-NO: 5649030

DOCUMENT-IDENTIFIER: US 5649030 A

**** See image for Certificate of Correction ****TITLE: Vector quantization

DATE-ISSUED: July 15, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Normile; James Oliver	Sunnyvale	CA		
Wang; Katherine Shu-Wei	San Jose	CA		

US-CL-CURRENT: 382/253; 348/417.1, 348/418.1, 382/251

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw Dg
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

☐ 12. Document ID: US 5596659 A

L8: Entry 12 of 12

File: USPT

Jan 21, 1997

US-PAT-NO: 5596659

DOCUMENT-IDENTIFIER: US 5596659 A

**** See image for Certificate of Correction ****TITLE: Preprocessing and postprocessing for vector quantization

DATE-ISSUED: January 21, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Normile; James O.	Sunnyvale	CA		
Wang; Katherine S.	San Jose	CA		
Wu; Hsi-Jung	Cupertino	CA		

US-CL-CURRENT: 382/253; 348/422.1, 382/299

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KIMC	Draw Da
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	---------

Clear

Generate Collection

Print

Fwd Refs

Bkwd Refs

Generate OACS

Terms

Documents

L7 and (multimedia or multi-media) and
vector\$2 and train\$3 and classif\$8 and quant\$

12

Display Format: -

Change Format

[Previous Page](#)[Next Page](#)[Go to Doc#](#)

Refine Search

Search Results -

Terms	Documents
(classify classification) and ((audiovisual audio visual video) same (score and database)) and train and vector	23

Database:

US Pre-Grant Publication Full-Text Database
 US Patents Full-Text Database
 US OCR Full-Text Database
 EPO Abstracts Database
 JPO Abstracts Database
 Derwent World Patents Index
 IBM Technical Disclosure Bulletins

Search:

L18

Refine Search

Recall Text

Clear

Interrupt

Search History

 DATE: Monday, January 16, 2006 [Printable Copy](#) [Create Case](#)

<u>Set</u> <u>Name</u> side by side	<u>Query</u>	<u>Hit</u> <u>Count</u>	<u>Set</u> <u>Name</u> result set
	<i>DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=NO; OP=OR</i>		
<u>L18</u>	(classify classification) and ((audiovisual audio visual video) same (score and database)) and train and vector	23	<u>L18</u>
<u>L17</u>	(classify classification) and ((audiovisual audio visual video) same (scorer and database)) and train and vector	0	<u>L17</u>
<u>L16</u>	classify and audiovisual and score and train and vector and database	19	<u>L16</u>
<u>L15</u>	L10 and video and (score or rank\$)	4	<u>L15</u>
<u>L14</u>	L11 and (score or rank\$)	0	<u>L14</u>
<u>L13</u>	L9 and (score or rank\$)	8	<u>L13</u>
<u>L12</u>	L11 and dictionar\$	1	<u>L12</u>
<u>L11</u>	L8 and database	3	<u>L11</u>
<u>L10</u>	L6 and database	5	<u>L10</u>
<u>L9</u>	L4 and database	12	<u>L9</u>

<u>L8</u>	L7 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	12	<u>L8</u>
<u>L7</u>	382/253	654	<u>L7</u>
<u>L6</u>	L5 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	7	<u>L6</u>
<u>L5</u>	382/160	226	<u>L5</u>
<u>L4</u>	L3 and quant\$	16	<u>L4</u>
<u>L3</u>	L1 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	23	<u>L3</u>
<u>L2</u>	L1 (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	1911	<u>L2</u>
<u>L1</u>	382/159	912	<u>L1</u>

END OF SEARCH HISTORY

Refine Search

Search Results -

Terms	Documents
(classify classification) and ((audiovisual audio visual video) same (score and database)) and train and vector	23

Database:

US Pre-Grant Publication Full-Text Database
 US Patents Full-Text Database
 US OCR Full-Text Database
 EPO Abstracts Database
 JPO Abstracts Database
 Derwent World Patents Index
 IBM Technical Disclosure Bulletins

Search:

L18

Refine Search

Recall Text

Clear

Interrupt

Search History

DATE: Monday, January 16, 2006 [Printable Copy](#) [Create Case](#)

<u>Set</u> <u>Name</u>	<u>Query</u>	<u>Hit</u> <u>Count</u>	<u>Set</u> <u>Name</u> result set
side by side			
<i>DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=NO; OP=OR</i>			
<u>L18</u>	(classify classification) and ((audiovisual audio visual video) same (score and database)) and train and vector	23	<u>L18</u>
<u>L17</u>	(classify classification) and ((audiovisual audio visual video) same (score and database)) and train and vector	0	<u>L17</u>
<u>L16</u>	classify and audiovisual and score and train and vector and database	19	<u>L16</u>
<u>L15</u>	L10 and video and (score or rank\$)	4	<u>L15</u>
<u>L14</u>	L11 and (score or rank\$)	0	<u>L14</u>
<u>L13</u>	L9 and (score or rank\$)	8	<u>L13</u>
<u>L12</u>	L11 and dictionary\$	1	<u>L12</u>
<u>L11</u>	L8 and database	3	<u>L11</u>
<u>L10</u>	L6 and database	5	<u>L10</u>
<u>L9</u>	L4 and database	12	<u>L9</u>

<u>L8</u>	L7 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	12	<u>L8</u>
<u>L7</u>	382/253	654	<u>L7</u>
<u>L6</u>	L5 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	7	<u>L6</u>
<u>L5</u>	382/160	226	<u>L5</u>
<u>L4</u>	L3 and quant\$	16	<u>L4</u>
<u>L3</u>	L1 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	23	<u>L3</u>
<u>L2</u>	L1 (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	1911	<u>L2</u>
<u>L1</u>	382/159	912	<u>L1</u>

END OF SEARCH HISTORY

Refine Search

Search Results -

Terms	Documents
L19 or L18	24

Database:

US Pre-Grant Publication Full-Text Database
 US Patents Full-Text Database
 US OCR Full-Text Database
 EPO Abstracts Database
 JPO Abstracts Database
 Derwent World Patents Index
 IBM Technical Disclosure Bulletins

Search:

Search History

DATE: Monday, January 16, 2006 [Printable Copy](#) [Create Case](#)

<u>Set</u> <u>Name</u> side by side	<u>Query</u>	<u>Hit</u> <u>Count</u>	<u>Set</u> <u>Name</u> result set
	<i>DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=NO; OP=OR</i>		
<u>L20</u>	L19 or L18	24	<u>L20</u>
<u>L19</u>	(pattern near3 (match matching)) and ((audiovisual audio visual video) same (score and database)) and train and vector	7	<u>L19</u>
<u>L18</u>	(classify classification) and ((audiovisual audio visual video) same (score and database)) and train and vector	23	<u>L18</u>
<u>L17</u>	(classify classification) and ((audiovisual audio visual video) same (scorer and database)) and train and vector	0	<u>L17</u>
<u>L16</u>	classify and audiovisual and score and train and vector and database	19	<u>L16</u>
<u>L15</u>	L10 and video and (score or rank\$)	4	<u>L15</u>
<u>L14</u>	L11 and (score or rank\$)	0	<u>L14</u>
<u>L13</u>	L9 and (score or rank\$)	8	<u>L13</u>
<u>L12</u>	L11 and dictionar\$	1	<u>L12</u>
<u>L11</u>	L8 and database	3	<u>L11</u>

<u>L10</u>	L6 and database	5	<u>L10</u>
<u>L9</u>	L4 and database	12	<u>L9</u>
<u>L8</u>	L7 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	12	<u>L8</u>
<u>L7</u>	382/253	654	<u>L7</u>
<u>L6</u>	L5 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8 and quant\$	7	<u>L6</u>
<u>L5</u>	382/160	226	<u>L5</u>
<u>L4</u>	L3 and quant\$	16	<u>L4</u>
<u>L3</u>	L1 and (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	23	<u>L3</u>
<u>L2</u>	L1 (multimedia or multi-media) and vector\$2 and train\$3 and classif\$8	1911	<u>L2</u>
<u>L1</u>	382/159	912	<u>L1</u>

END OF SEARCH HISTORY

IEEE Pacific Rim Conference on Communications, Computers and Signal Processing
June 1st - 2nd, 1989
SPEECH QUALITY ASSESSMENT USING EXPERT PATTERN RECOGNITION TECHNIQUES

Robert F. Kubichek, Edmund A. Quincy, and Kevin L. Kiser
Institute for Telecommunication Sciences
National Telecommunications and Information Administration
U. S. Department of Commerce
325 Broadway, Boulder, CO U.S.A.
(303) 497-3594

Abstract

Automatic assessment of voice transmission quality is increasingly important to users and providers of communication services and products. Human listener panels currently provide subjective voice quality information. However, this approach can be slow, expensive, and unreliable. An objective method for assessing quality based on statistical pattern recognition and expert system techniques is described here.

1. Introduction

Background

Assessment of voice transmission quality is important to users and providers of telecommunication services, as well as to standards organizations. Unfortunately, subjective assessment using human listeners can be expensive, slow, and unreliable. Development of an accurate and consistent objective method for voice quality assessment represents an important and widespread need.

Recent efforts to develop an objective measure of voice quality are based on parameters measured directly from the input and output speech [1-4]. While several proposed objective parameters have shown good correlation with subjective scores for some types of distortion, further study is required to determine their effectiveness over a wide variety of conditions and impairments.

System Overview

This paper proposes an Expert Pattern Recognition (EPR) system for objective voice quality assessment. The proposed system uses a combination of expert systems techniques and statistical pattern recognition (SPR) methods. It offers several potential advantages over previous methods based on a single voice parameter: (1) This is a multivariate technique that uses an optimized set of objective parameters for improved accuracy; (2) In addition to predicting Mean Opinion Score (MOS), the system estimates opinion score frequencies, i.e. the probability of each quality class: P(excellent), P(good), P(fair), P(poor), P(unacceptable); (3) Expert system techniques provide the capability to logically integrate SPR results with other knowledge bases to account for factors such as transmission delay, which are not dealt with in the SPR system.

The system first undergoes a training phase, which selects rules and facts for the expert system and statistical parameters for the SPR design. Training requires a speech database containing a standard speech

source, processed speech representing impairments relevant to the intended applications, and complete subjective scores for the processed speech. Using the training data, an optimum set of voice parameters is selected from over 200 candidates using a bottom-up evaluation technique described below. The parameter set's probability density function is estimated for each type of distortion using a Gaussian mixture model (i.e. weighted sum of Gaussian functions). These densities define the statistical parameters for the SPR system.

In the second phase, standard voice source is played into the device or channel being tested, and an assessment is made on the output signal. Objective parameter values are measured and analyzed by the EPR system, which uses training statistics to produce the quality assessment. This process is illustrated in Fig. 1 and is described below.

2. Parameter Evaluation

The system is capable of using multiple voice parameters for its assessment. Many of the parameters used in this research were adapted from published work in voice quality, speaker identification, and speech recognition. An evaluation algorithm is used to identify a small subset of these parameters that will provide the best possible performance.

Parameter Measurement

Parameters are measured on either the output (impaired) speech only, or they measure distortion between input and output speech. Some examples of measured parameters are

- Output speech parameters: linear predictive coding (LPC) related measures including partial correlation (PARCOR) coefficients, log area ratios, and cepstral coefficients; spectral measures such as spectral flatness and average power weighted frequency
- Distortion parameters: signal-to-noise ratio; measures of spectral distortion; coherence-based measures such as signal-to-distortion ratio in particular frequency bands; cepstral distance

Search Method

Maximum system performance is realized only with an optimum set of objective parameters. Exhaustive evaluation of all possible combinations of parameters yields an optimal parameter set but is computationally prohibitive. Thus, a more useful approach is a suboptimal, "bottom-up" search that examines only selected combinations [5]. The algorithm successively adds parameters that most improve performance and removes parameters that are no longer useful.

There are several metrics for evaluating performance. Two useful metrics are chi-squared error and mean-squared error of predicted MOS. Chi-squared error is

This work is supported in part by National Communications System under R. O. 7-10349. The authors wish to thank AT&T Bell Labs and COMSAT Labs for providing subjectively classified speech data for this project.

measured between the predicted opinion score frequencies and the known listener panel opinion score frequencies. It measures the system's ability to model the listener panel and provides an overall measure of prediction accuracy. In contrast, the mean-squared error metric only measures how well the system predicts mean opinion score and is therefore less useful than the chi-squared error metric.

3. Voice Quality Classification and Prediction

Voice quality prediction is accomplished by analyzing training data from representative types of distortions. A statistical assessment is formed from the estimated probability density functions of the voice parameters. This assessment consists of estimated opinion score probabilities, mean opinion score, and most likely opinion score.

Distortion Probability

A vector of parameters measured from the i -th frame of the test speech (unknown voice quality), X_i , is represented by x_i . $p(x_i|d_m)$ is the conditional probability density function of x_i for the m -th distortion. It is estimated using a k -nearest neighbor method [6] by

$$p(x_i|d_m) = (k-1) / (N_{dm} \cdot v(x_i)). \quad (1)$$

Here, N_{dm} is the total number of training samples in the m -th distortion, and $v(x_i)$ is the volume of a hypersphere with radius equal to the distance to the k -th nearest vector belonging to distortion d_m . A quick multimodal estimate of $p(x_i|d_m)$ can also be formed by modeling the density as a Gaussian mixture. Typically, (1) is used during feature evaluation and selection, while the Gaussian mixture is used for classifier design.

The probability of distortion d_m is given by the Bayes relationship

$$P(d_m|x_i) = \frac{p(x_i|d_m) \cdot P(d_m)}{\sum_j p(x_i|d_j) \cdot P(d_j)} \quad (2)$$

where $P(d_m)$ is the prior probability of the m -th distortion.

Opinion Score Probability

An estimate of the opinion score probability function, $P(\omega_q|x_i)$, can now be obtained. This is the probability of opinion score ω_q , where the classes range from $q=1$ (unacceptable) to $q=5$ (excellent). This function is interpreted as the predicted frequency of listener panel scores corresponding to test speech, x_i . The relationship is given by

$$P(\omega_q|x_i) = \sum_m P(d_m|x_i) \cdot P(\omega_q|x_i,d_m) \quad (3)$$

where $P(\omega_q|x_i,d_m)$ is the probability that opinion score ω_q is chosen given distortion d_m and parameter vector x_i . This function is approximated by the listener-panel relative frequencies for distortion d_m , given by $\hat{P}(\omega_q|x_i,d_m)$.

Classification and Mean Opinion Score Prediction

Having estimated class probability (3), we can now obtain a minimum probability-of-error classification of voice quality. This is given by the ω_q that gives the largest value of $P(\omega_q|x_i)$. It represents the quality level most likely to be selected by a listener panel member. In a similar fashion, (2) can be used to choose the most likely distortion.

The minimum mean-squared error prediction of Mean Opinion Score is found as:

$$MOS_i = \sum_{q=1}^5 q : P(\omega_q|x_i) \quad (4)$$

$$MOS = (\sum_{i=1}^N MOS_i) / N \quad (5)$$

where N is the number of parameter vectors used in the assessment.

Expert System

An expert system is being developed to handle impairments that are difficult to deal with using standard objective techniques. Examples include infrequent pops and clicks, delay and echo, time warping, and effects of TASI (time assignment speech interpolation) circuits. Other factors affecting voice quality are application dependent and may not be measurable from the speech. These include the user's nationality, hearing impairments, and expectations about grade of service. Rules and facts about human perception are being identified to specifically deal with these issues. The resultant knowledge base will embody information from a wide variety of studies dealing with the effects of such factors on voice quality. The expert system will use this knowledge base, along with the SPR assessment of each segment group, to create a final, overall quality classification.

4. Example Results

Figs. 2 through 5 demonstrate example results representing the major elements of the system. Fig. 2 shows results of applying the bottom-up evaluation procedure to identify an effective parameter set. Mean-squared error of predicted MOS is plotted against the number of iterations. Each iteration either adds or removes a parameter from the current parameter set in order to minimize error. For example, in the first iteration, the parameter LPC-04 is added and in the fifth iteration, parameter AUTOCRO5 is removed. The algorithm terminates on the seventh iteration when it can find no way to further reduce the mean-squared error.

Fig. 3 shows decision boundaries resulting from training the Bayes classifier. The speech parameter set consists of LPC-01 (horizontal axis) and LPC-05 (vertical axis). Cluster analysis results are indicated with unit standard deviation ellipses to represent cluster locations. These are used to form a Gaussian mixture estimate of the probability density for each impairment. Three types of training data are used: speech plus 0 dBRNC ("A" ellipses), 25 dBRNC ("B" ellipses), and 45 dBRNC ("C" ellipses) added noise. The most likely opinion score was derived using (2) and (3) and is depicted on the figure by different cross-hatching. Note that "A" ellipses (no added noise) are mostly located in regions of excellent (class 5) or good (class 4) quality. Similarly, "B" (25 dBRNC added noise) and "C" (45 dBRNC added noise) ellipses are located in regions of lower quality. As Fig. 3 shows, (3) the decision boundaries are also extrapolated into areas containing no training data.

* dBRNC refers to decibels above reference noise, C-message weighted.

Equations (1) through (5) are based on the assumption that parameter measurements are statistically stationary. Unfortunately, normal speech is only locally stationary, and this reduces system performance. The effect of nonstationarity is lessened by segmenting the speech prior to training. Each segment type is composed of statistically similar frames of speech. These are chosen using cluster analysis techniques. Fig. 4 shows an example of segmentation into five types, where five was chosen arbitrarily. Vertical lines relate the speech signal, on top, to the corresponding segment types, below. The SPR system is applied separately to each segment type, yielding multiple assessments that must be combined into a single quality prediction. This can be done using regression or expert system techniques. As expected, preliminary results indicate that segmentation improves assessment accuracy.

Fig. 5 shows the system's assessment of speech plus added noise. For this example, only four impairments were used to train the system. The predicted opinion score histogram is shown on top. A histogram of the listener panel opinion scores immediately follows. Also shown are predicted and actual MOS values, most likely opinion score, and distortion probabilities for the impairments used to train the classifier.

5. Conclusions

This paper has described a new technique for processing objective parameters to obtain voice quality assessment. The method combines statistical pattern recognition techniques with a knowledge-based expert system. The SPR module uses optimally selected voice parameters to form a purely statistical assessment of voice quality. Output includes a classification of the most likely opinion score, a prediction of mean opinion score, and the predicted opinion score frequencies. An expert system is being developed to combine these results with additional knowledge bases to account for factors such as delay, which are not accounted for by the SPR system.

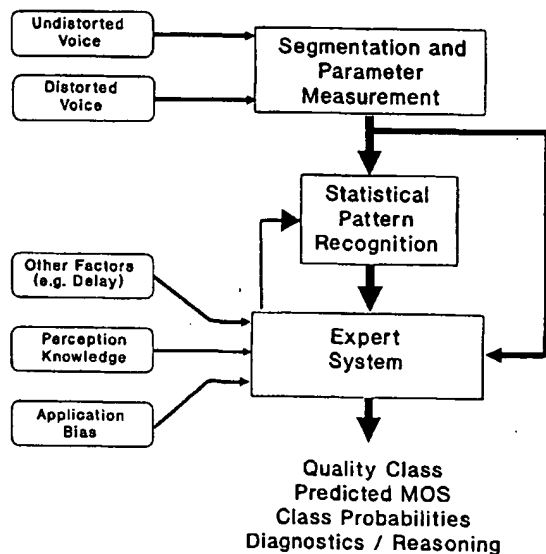


Fig. 1. System Overview.

References

- [1] B.J. McDermott, C. Scagliola, and D. Goodman, "Perceptual and objective evaluation of speech processed by adaptive differential PCM," *Bell Syst. Tech. J.*, vol. 57, no. 5, pp. 1597-1618, May-June 1978.
- [2] P. Mermelstein, "Evaluation of a segmental SNR measure as an indicator of the quality of ADPCM coded speech," *J. Acoust. Soc. Am.*, vol. 66, no. 6, pp. 1664-1667, Dec. 1979.
- [3] N. Kitawaki, H. Nagabuchi, and K. Itoh, "Objective quality evaluation for low-bit-rate speech coding systems," *IEEE J. on Sel. Areas in Communications*, vol. 6, no. 2, pp. 242-248, Feb. 1988.
- [4] E.A. Quincy, "PROLOG-based expert pattern recognition system shell for technology independent, user-oriented, classification of voice transmission quality," *Proceedings IEEE-ICC 87*, Vol. 2, pp. 1164-1171, June 1987.
- [5] J. Kittler, "Feature selection and extraction," *Handbook of Pattern Recognition and Image Processing*, T. Y. Young and K. S. Fu, ed., Academic Press, Inc., Chapter 3, pp. 59-83, 1986.
- [6] D.O. Loftsgaarden and C. P. Quesenberry, "A non-parametric estimate of a multivariate density function," *Annals of Mathematical Statistics*, vol. 36, pp. 1049-1051, June 1965.

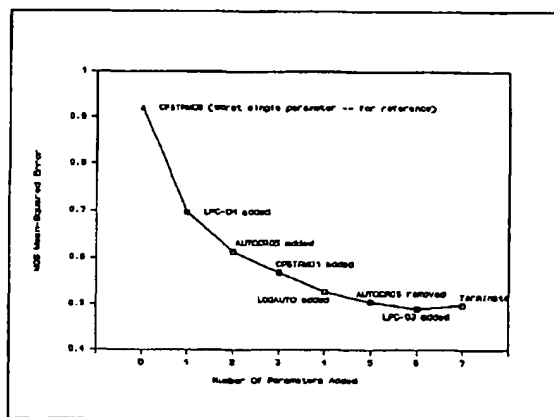


Fig. 2. MOS prediction error for parameter sets selected during a single bottom-up evaluation.

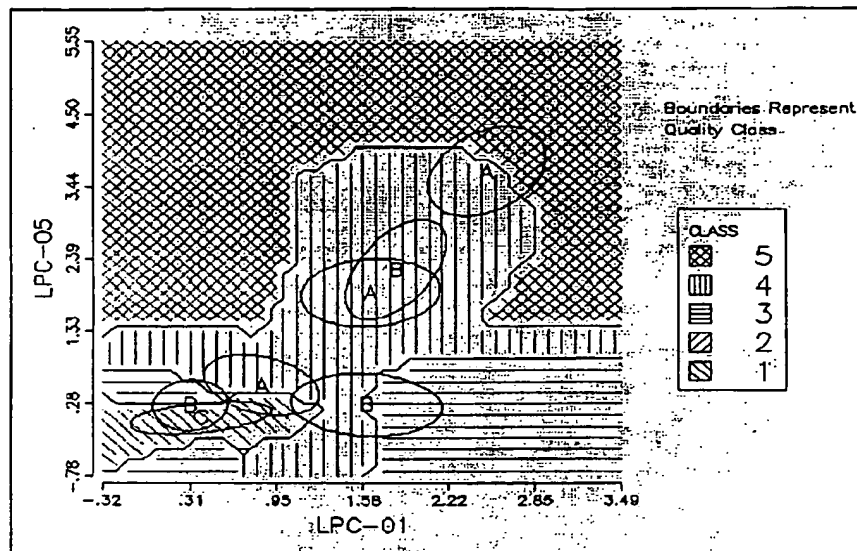


Fig. 3. Decision regions for most likely opinion score. Ellipses represent approximate training data locations for 0 dBNC ("A"), 25 dBNC ("B"), and 45 dBNC ("C") added noise.

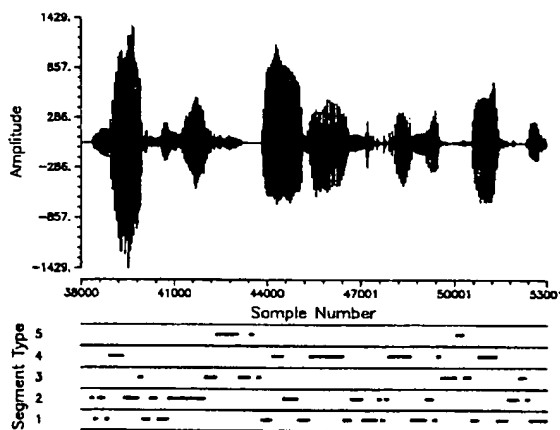


Fig. 4. Example of speech signal (above) and corresponding segment types (below).

OPINION SCORE FREQUENCY:		PREDICTED
1 (Unaccept.)	% 19.8	██████████
2 (Poor)	% 31.1	████████████████████
3 (Fair)	% 27.1	████████████████████
4 (Good)	% 15.1	██████████
5 (Excellent)	% 6.8	██████

OPINION SCORE FREQUENCY:		LISTENER PANEL
1 (Unaccept.)	% 9.1	████
2 (Poor)	% 47.7	██
3 (Fair)	% 34.1	████████████████████████████████████
4 (Good)	% 9.1	████
5 (Excellent)	% 0.0	

Predicted:	MOS: 2.6	Class: 2
Listener Panel:	MOS: 2.4	Class: 2

Distortion Probabilities:	SORCM2	0.10
	NS25M2	0.21
	NS35M2	0.35
	NS45M2	0.34

Fig. 5. Example system output showing predicted and listener panel quality assessments: opinion score frequency, MOS, most likely opinion score (class), and distortion probabilities for four training impairments.